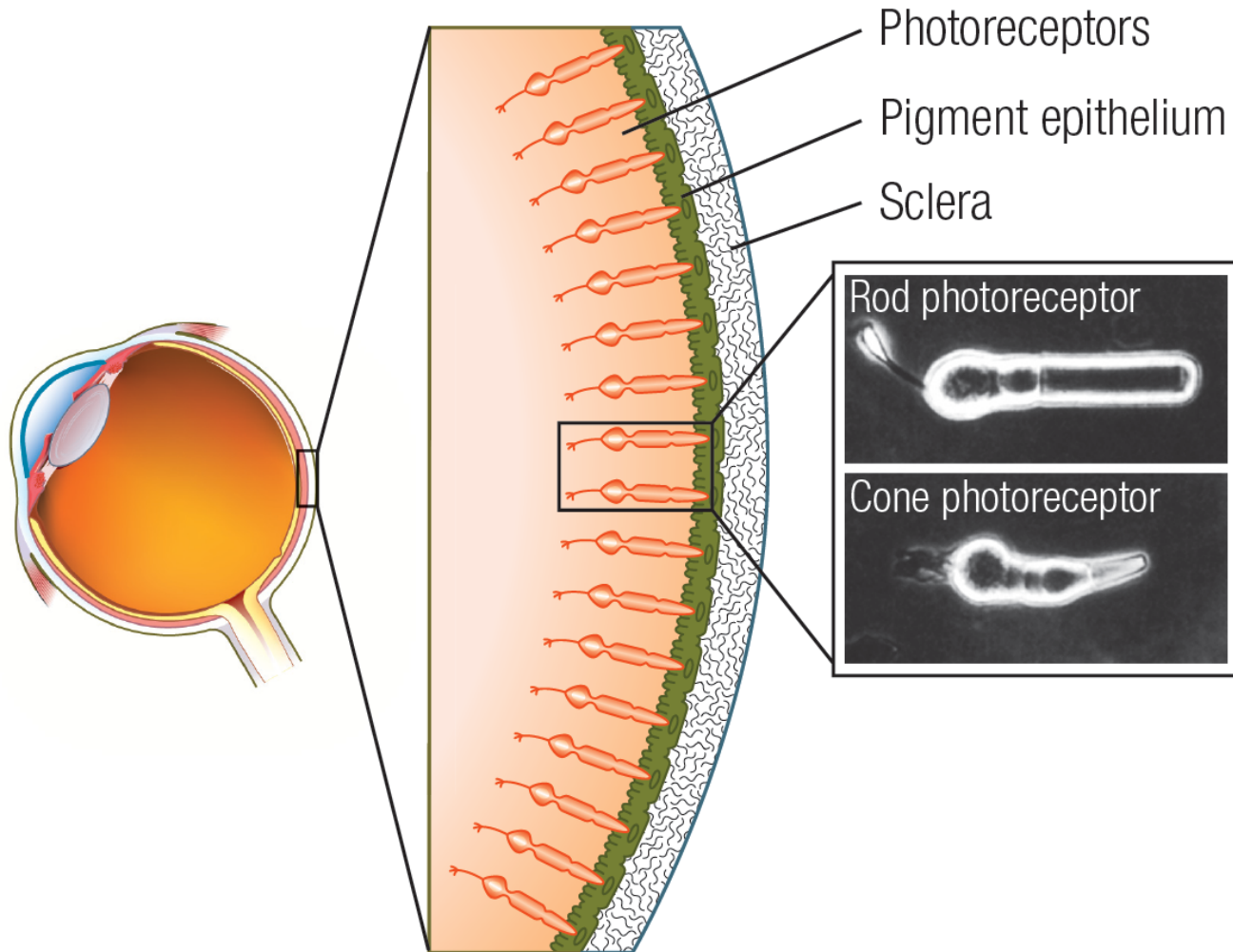
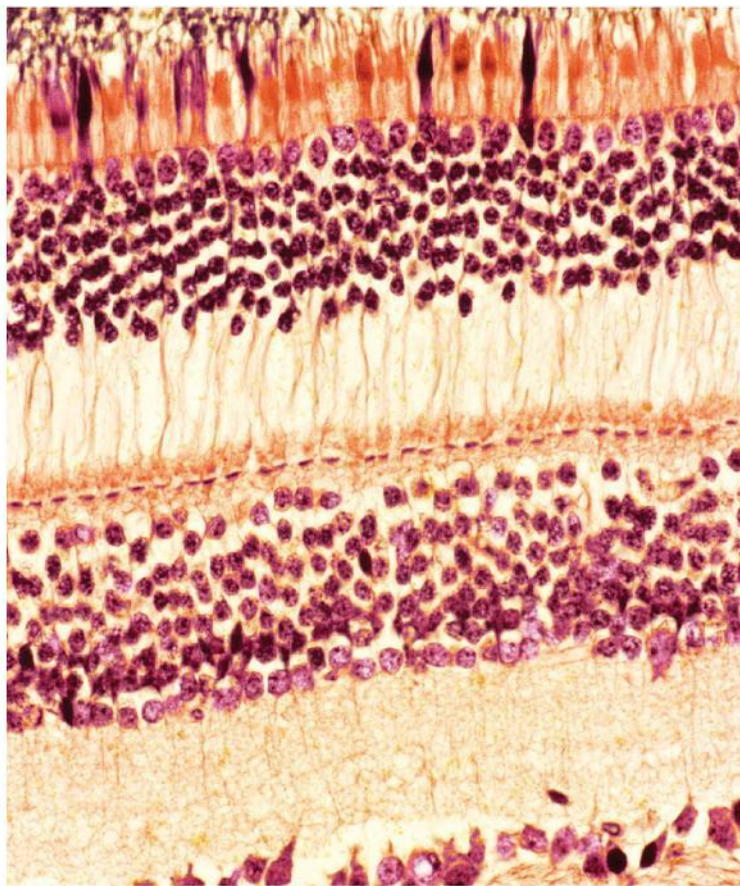
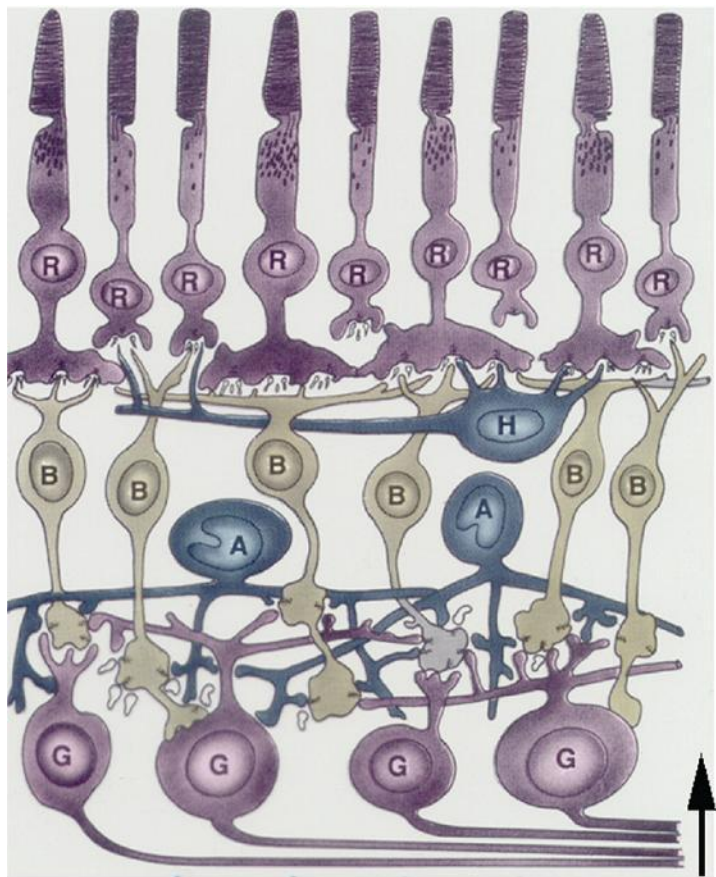


Photoreceptors and Phototransduction

Macro-Anatomy of Retina



Cross-section of Retina



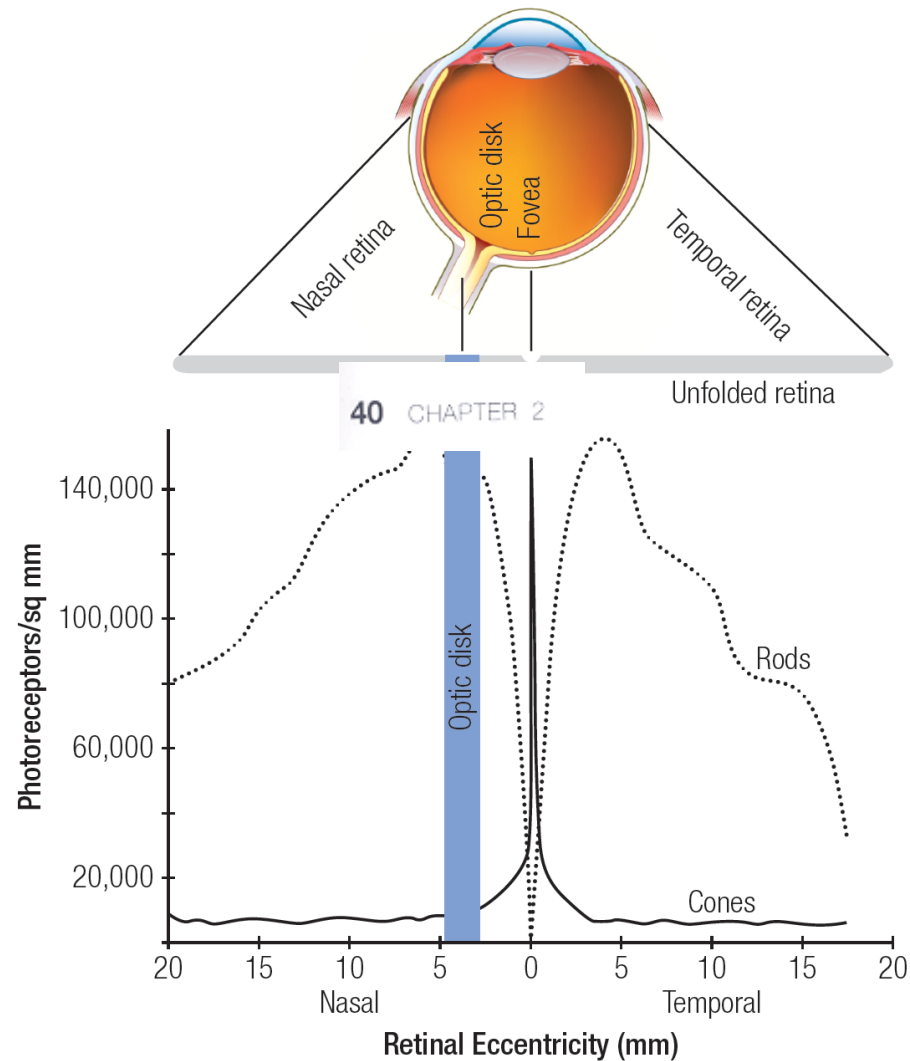
Pigment
epithelium

Photoreceptor
layer

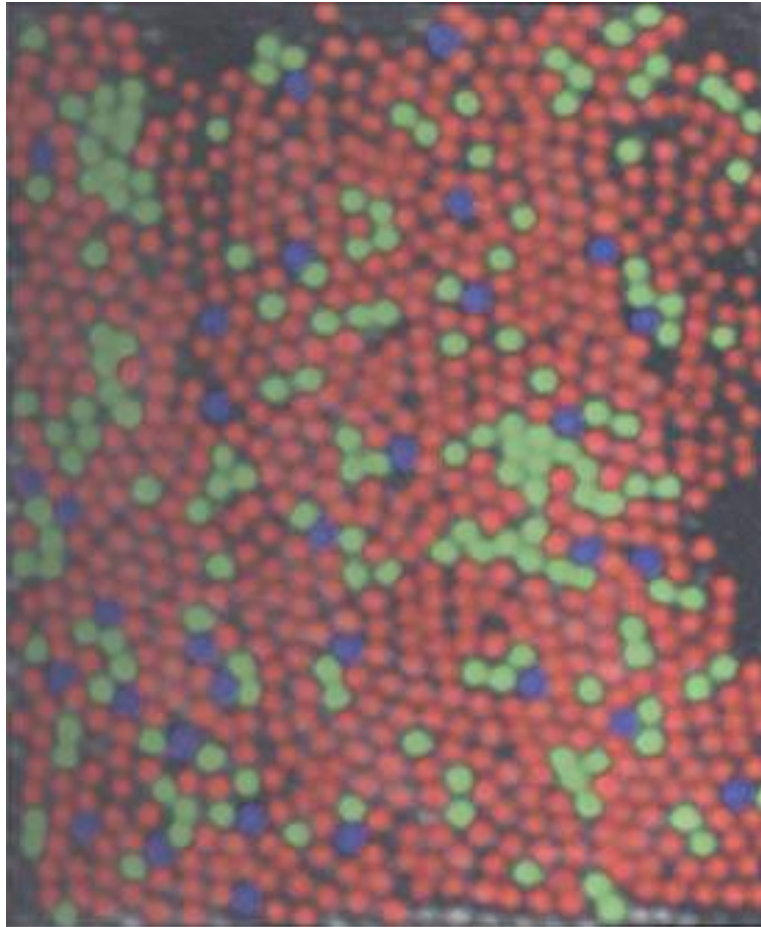
Inner nuclear
layer

Ganglion cell
layer

Photoreceptor Distribution

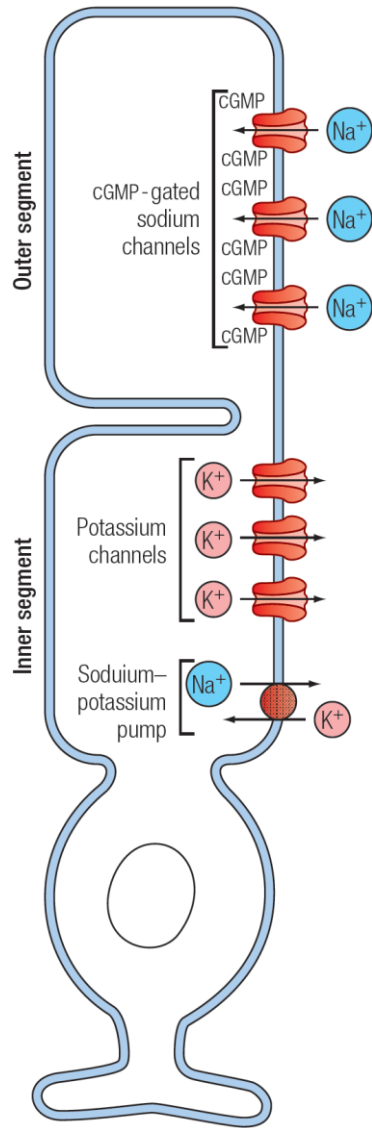


Macular Cone Mosaic



Transduction

Photoreceptor at “Rest”



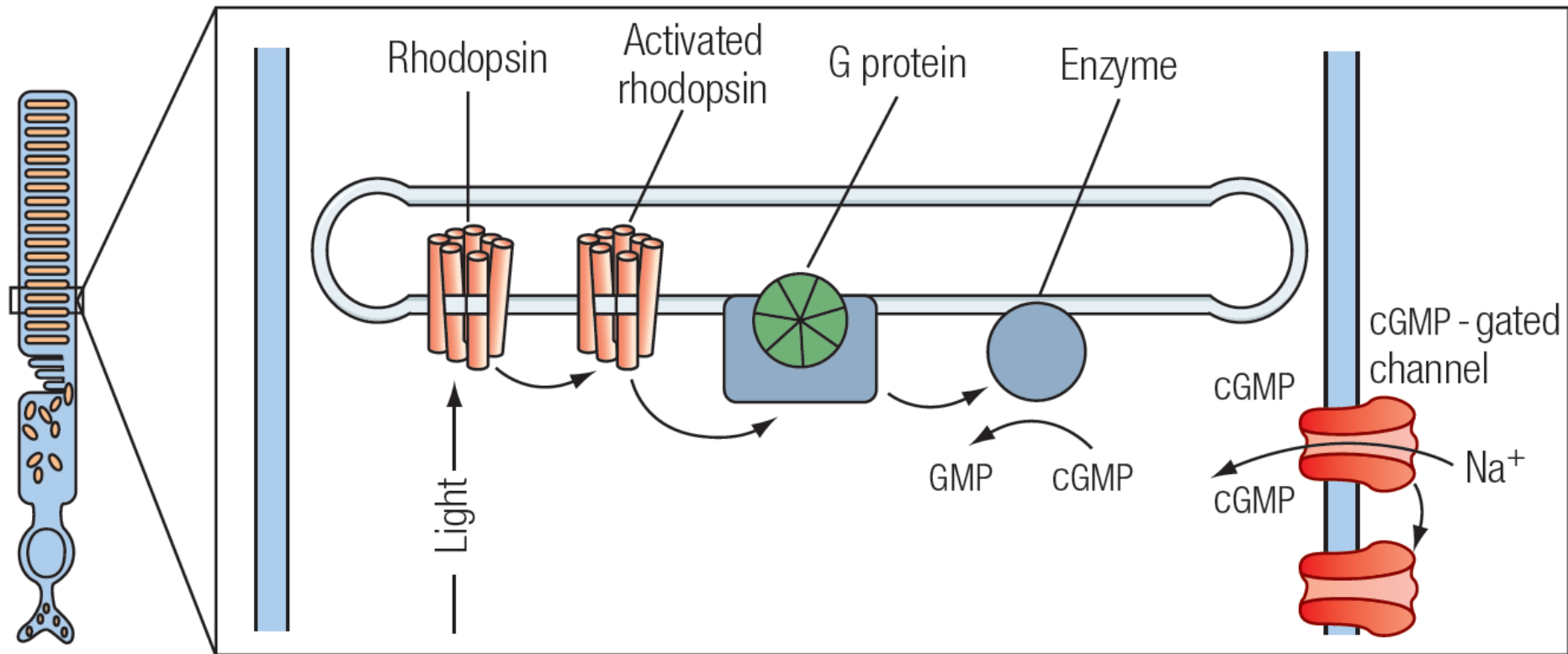
cGMP-energized Na⁺ pump imports + ions into outer segment

K⁺ ions pumped out of inner segment

Net result is “resting potential” of -40 mv in the dark (so-called “dark current”)

Reminder: Na = sodium; K = potassium

Photo-transduction Cascade



Transduction Cascade (cont.)

Photopigment absorbs photon(s) and “changes shape”

Isomerization of photopigment activates enzyme which converts cGMP to GMP

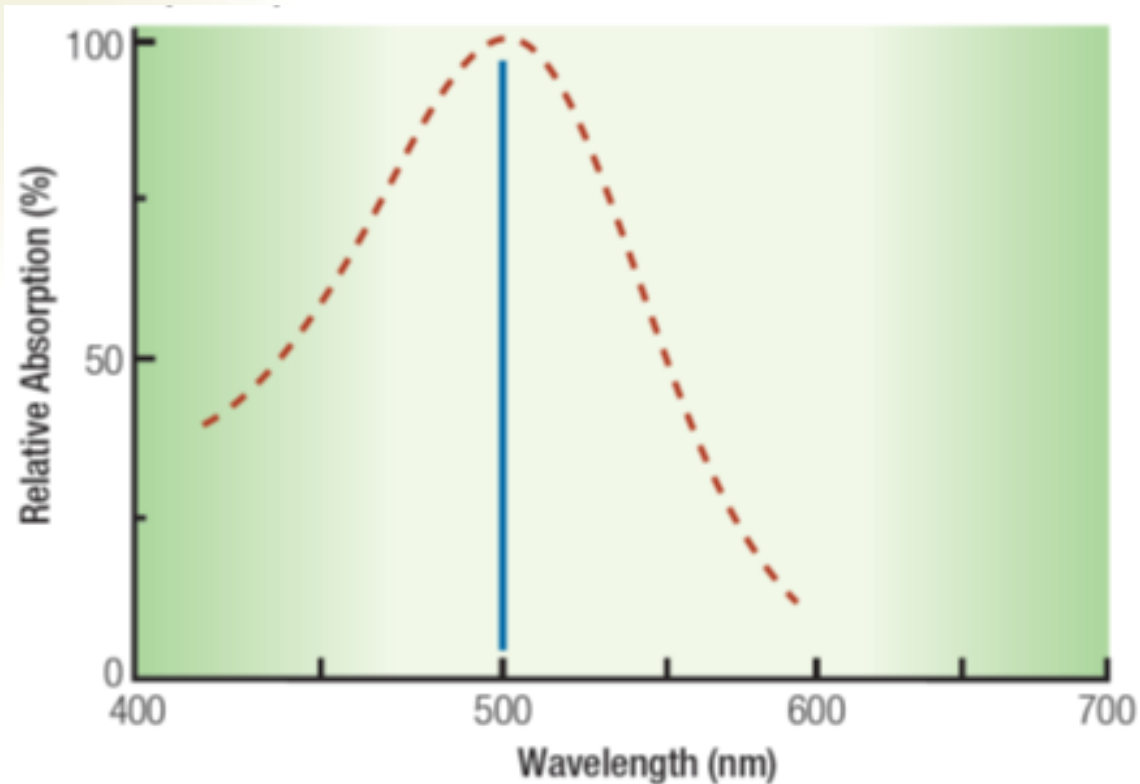
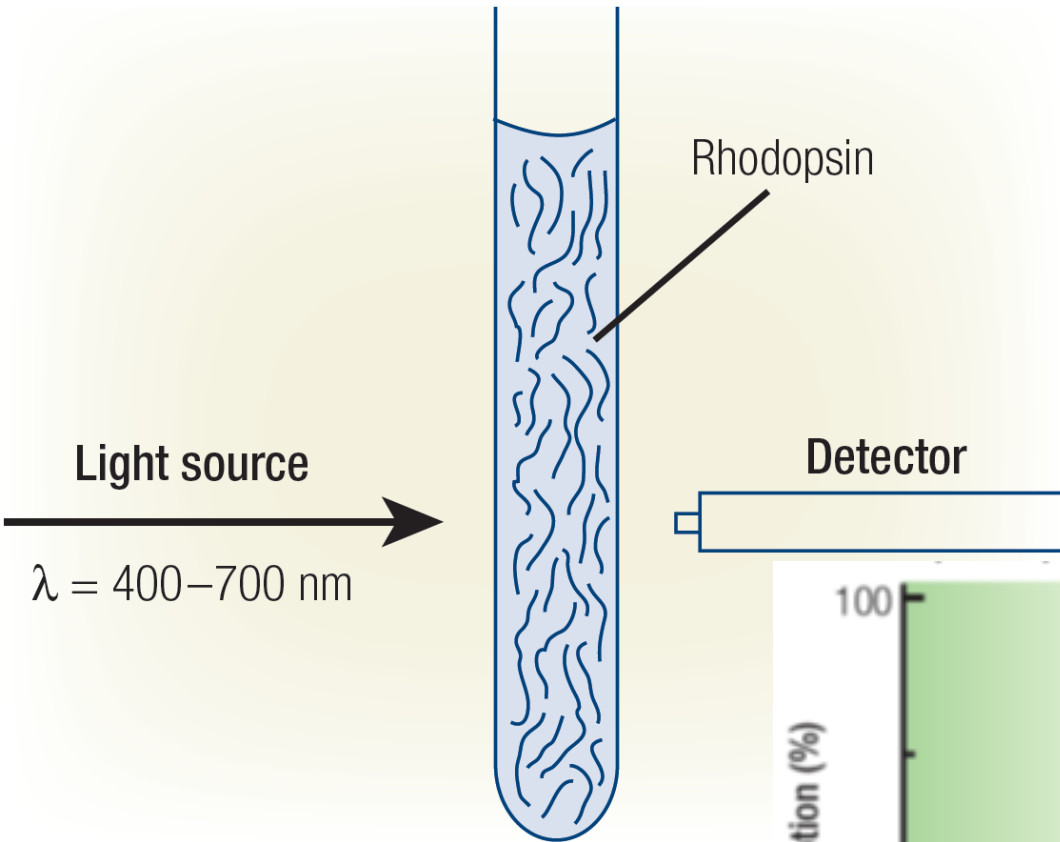
Reduced availability of cGMP shutsdown outer segment Na⁺ pumps

Continued outbound K⁺ by inner segment pump increase the net negative charge across the cell membrane (from -40 to as high as -70 mV) **Hyperpolarization rather than depolarization**

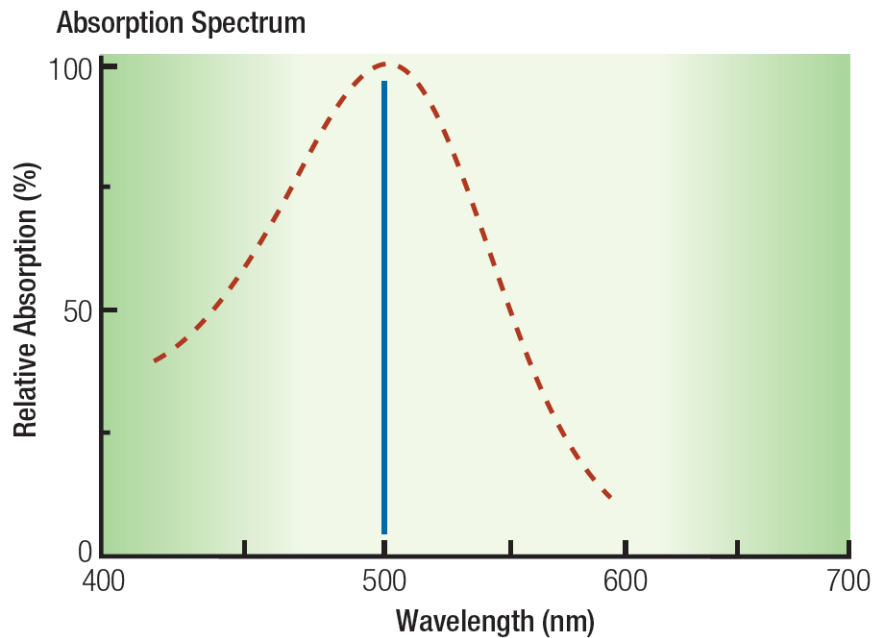
Hyperpolarization inhibits release of glutamate neurotransmitter

Spectral Sensitivity of the Photoreceptors

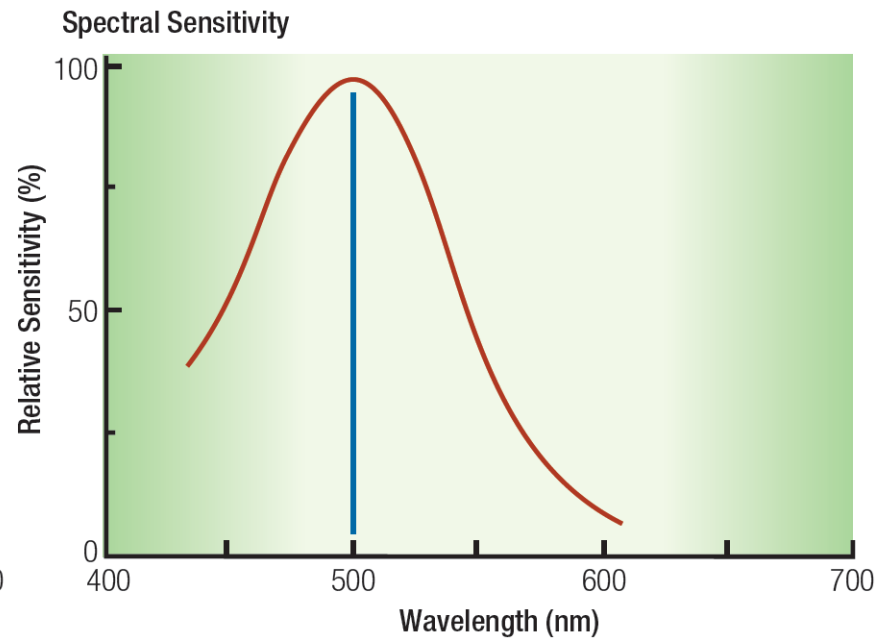
Rhodopsin Spectra



Absorption Spectrum versus Visual Sensitivity Function



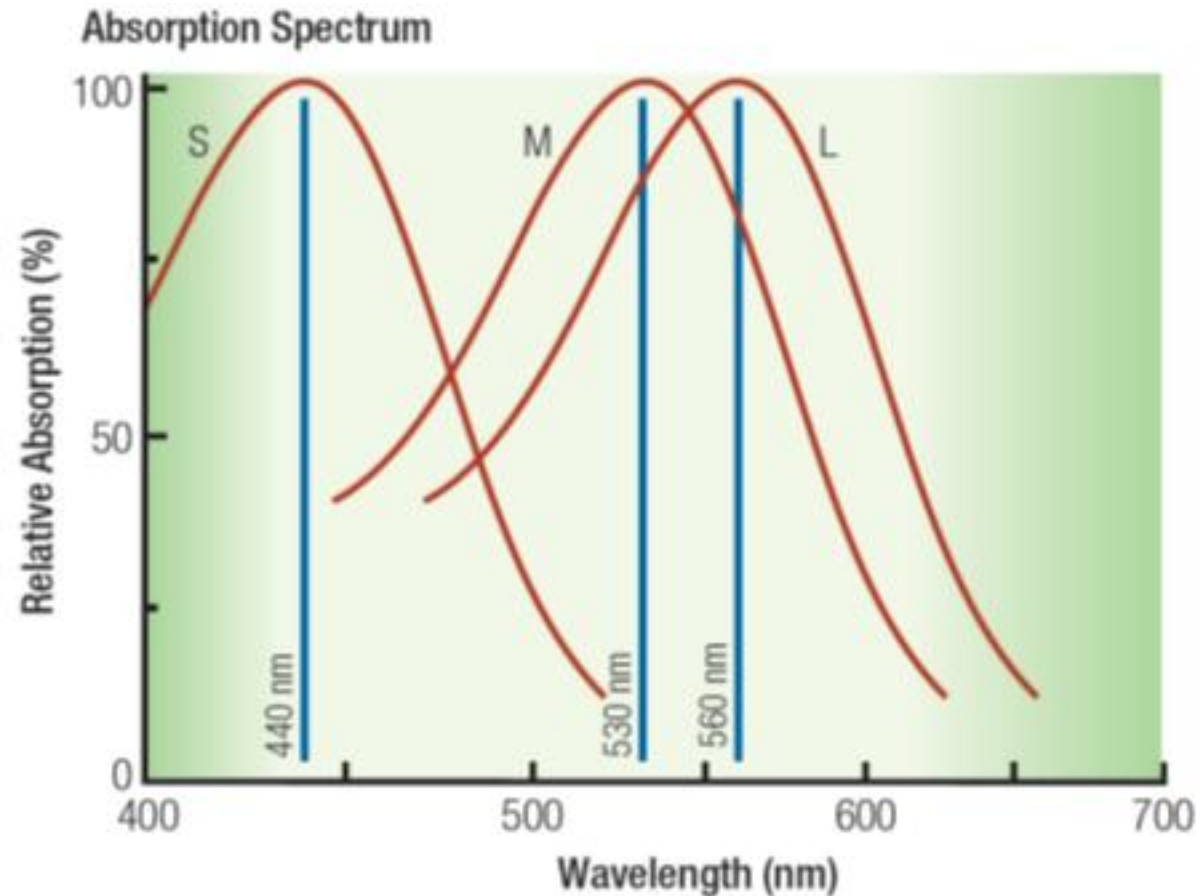
Rhodopsin



**Sensitivity for Peripheral Stimulus
(Dark Adapted Eye)**

Scotopic Visibility Function (V'_λ)

Absorption Spectra for “Blue”, “Green” and “Red” Cones

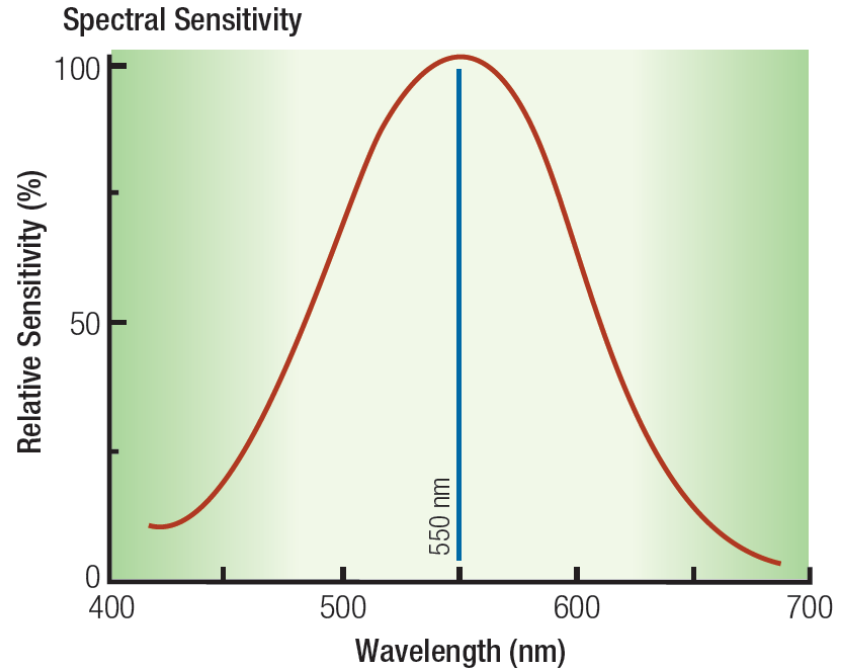
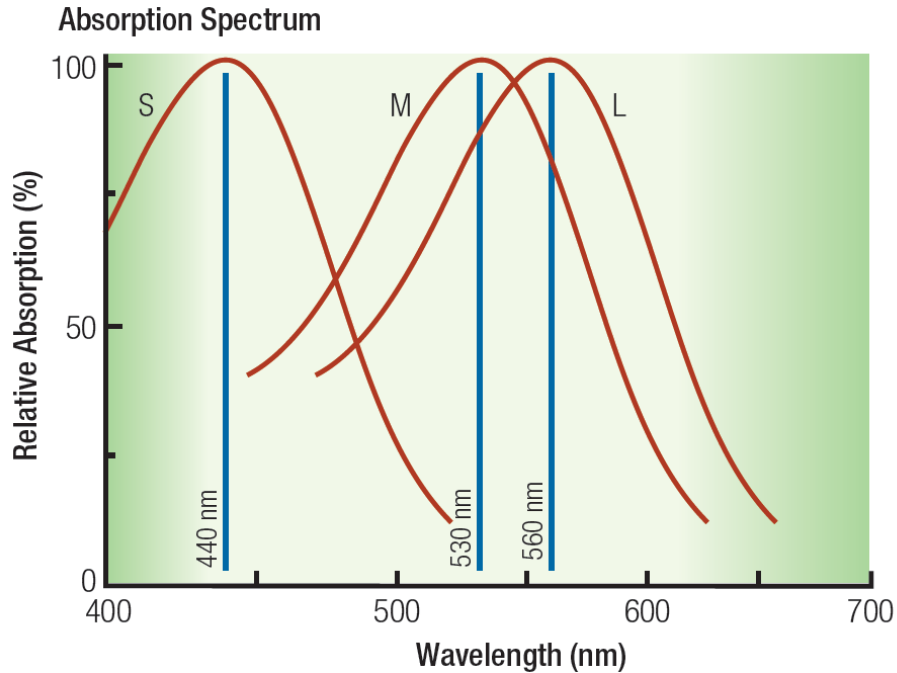


S-cone 440 nm Blue

M-cone 530 nm Y-G

L-cone 560 nm R-Y

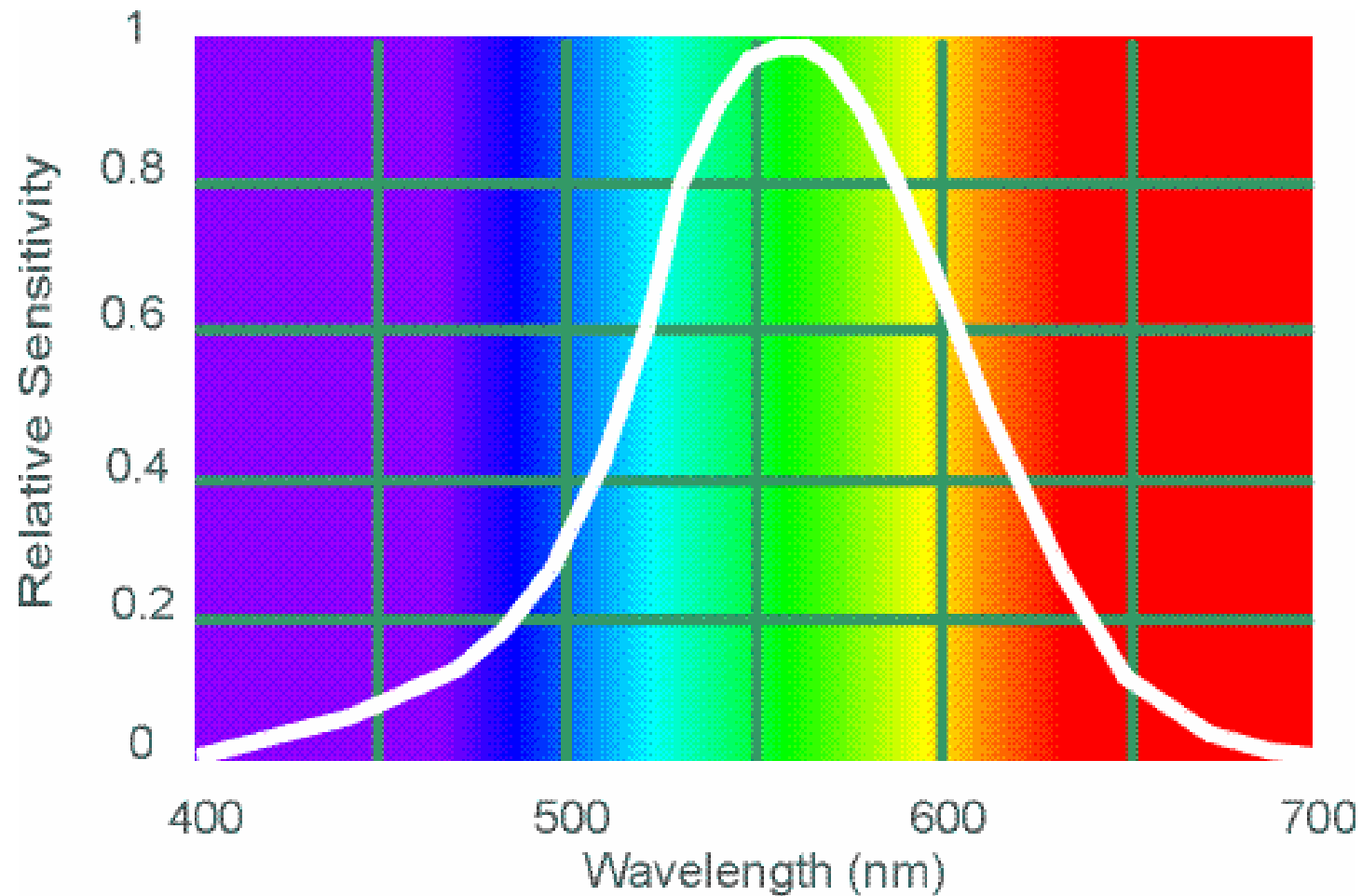
Cone Absorption Spectra versus Foveal Sensitivity Function



Photopic Visibility Function

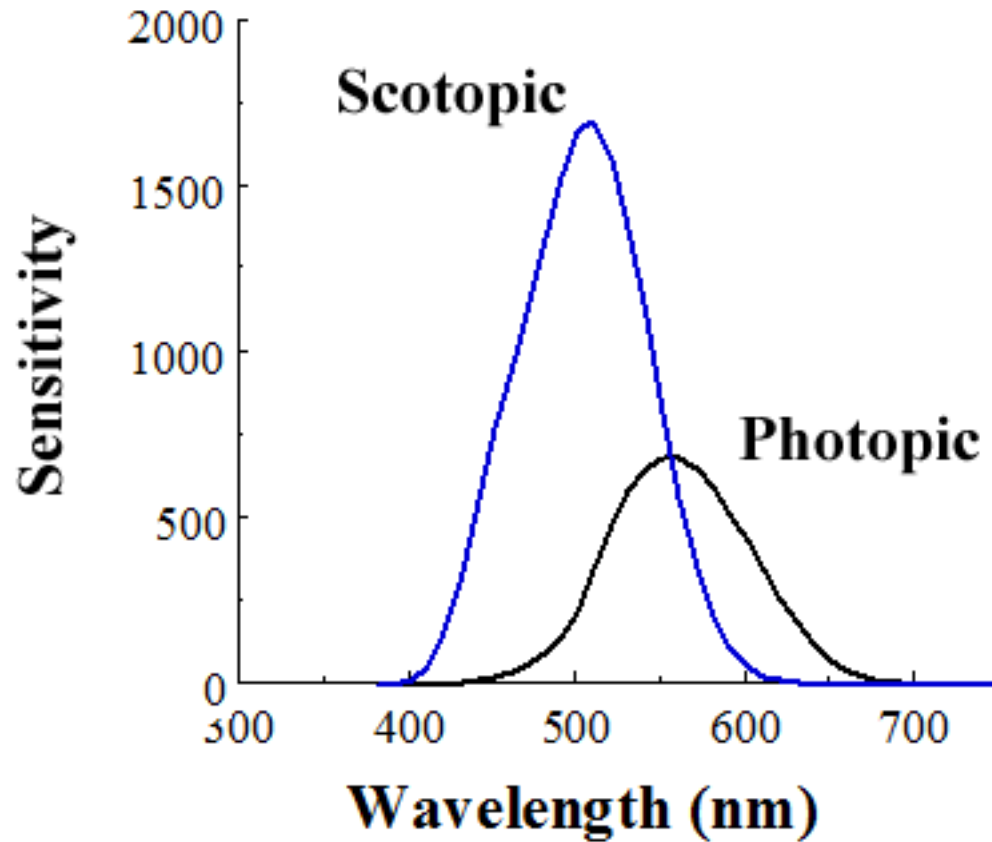
(V_λ)

Photopic Visibility Function (V_λ)

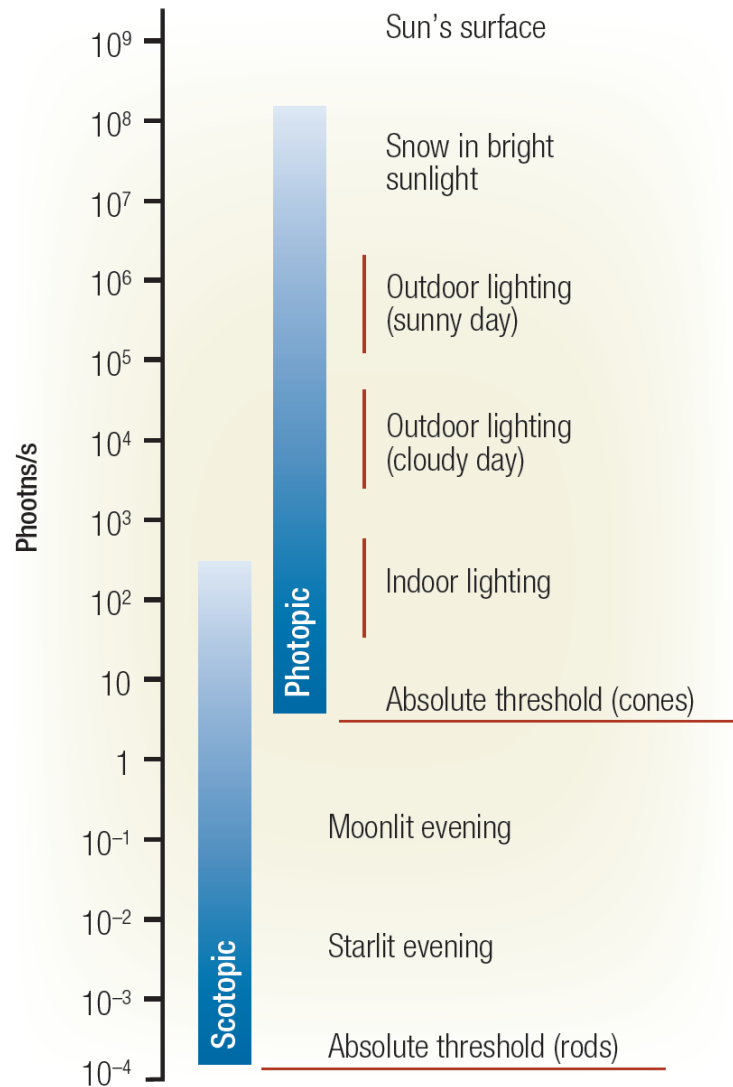


Scotopic vs. Photopic Vision

Absolute Sensitivity Curves

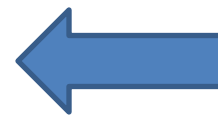


Scotopic vs. Photopic Domains



“scotos” = dark

“photos” = light



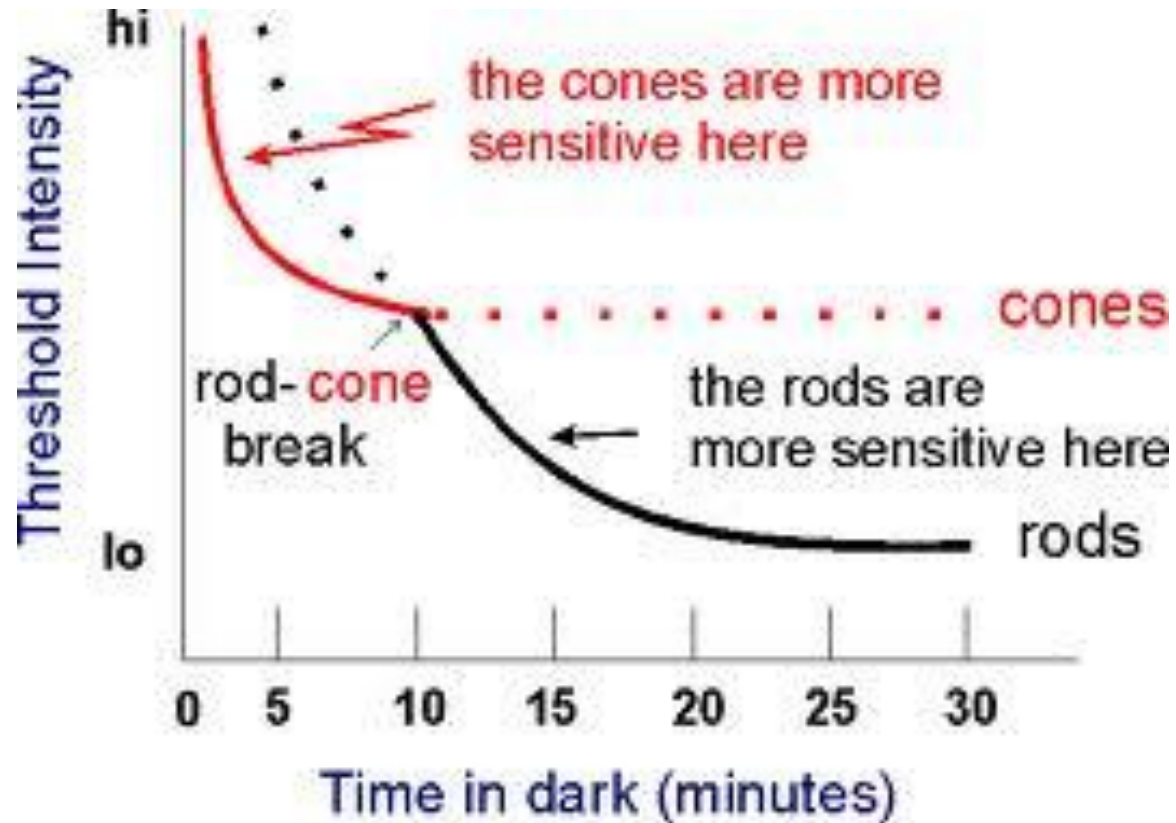
Mesopic Range

Scotopic/Photopic Dichotomy

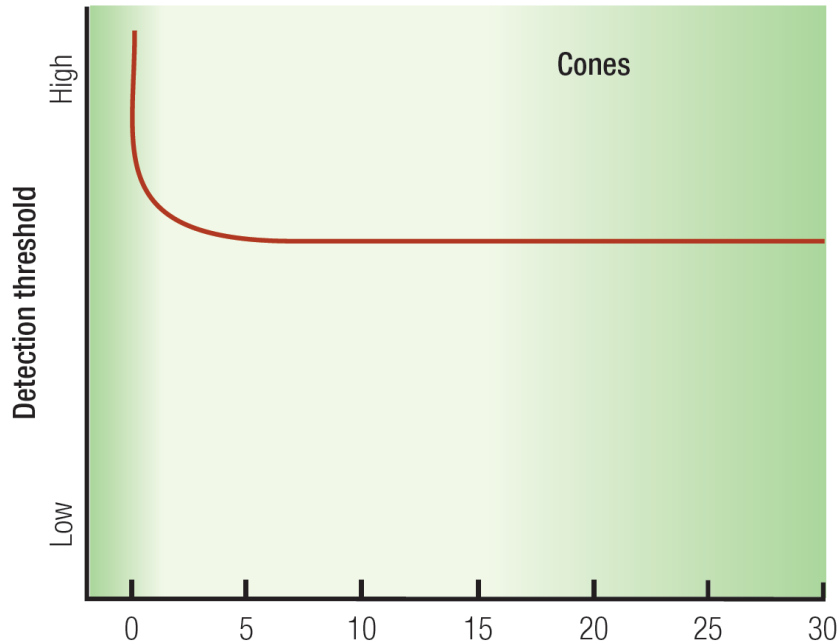
Property	Scotopic	Photopic
Photoreceptor	Rods (120 M)	Cones (5-8 M)
Retinal Distribution	Peripheral	Central
Temporal Response	Slow	Fast
Ganglion Cell Convergence	High (100's:1)	Low (Few:1)
Spatial Resolution	Low	High
Light Sensitivity	High	Low
Wavelength Discrimination	No (505)	Yes (440; 530; 560)

Dark Adaptation Function

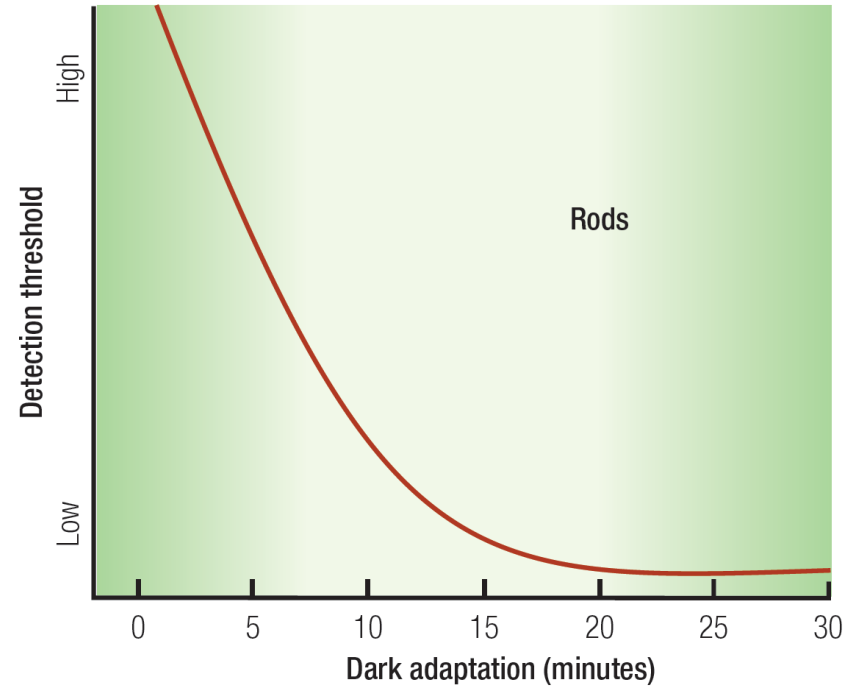
Classic Dark Adaptation Curve



Isolated Rod vs. Cone Dark Adaptation Curves



Fast Cone Recovery



Slow Rod Recovery